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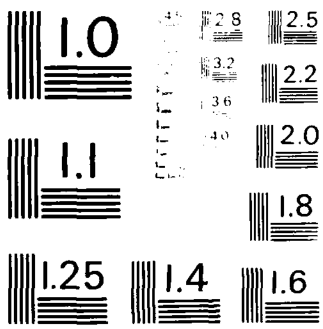
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AD-A141 981

WIND-GENERATED NOISE IN SHALLOW WATER

by

Melchiorre C. FERLA and William A. KUPERMAN

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1 April 1984

This report has been prepared as part of Project 19.

APPROVED FOR DISTRIBUTION

Ralph R. Goodman

RALPH R. GOODMAN
Director

TABLE OF CONTENTS

List of Figures

WIND-GENERATED NOISE IN SHALLOW WATER

by

Melchiorre C. Ferla and William A. Kuperman*

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ABSTRACT

An experiment was conducted in a shallow water region of the Mediterranean Sea to study wind-generated noise. In addition to measuring the noise field, propagation-loss data were collected and used in a detailed modelling of the environment. The environmental information was then used as input to a noise model based on wave theory that computes the noise field in the water column for a given (unknown) source strength. By comparing model predictions with data, the influence of the environment on recorded noise levels could be removed and a measure of the noise source spectrum levels obtained as a function of wind speed, which is the parameter that was determined to be more closely correlated to the noise level than is wave height.

INTRODUCTION

In almost all areas, wind is the dominant noise component over a significant frequency band, being overshadowed only occasionally by noise due to rain, ships, other human activities, and biological activities. The large spread of wind-generated noise levels measured for the same wind speed and wave height in the absence of other noise sources is caused not only by differences in the duration, fetch, and constancy of the wind, but also by the site-dependence of factors that control acoustic propagation, such as the sound-speed profile, the ocean depth, and the bottom composition <1,2,3>.

The purpose of this report is twofold: to present the wind-induced noise levels derived from ambient-noise measurements conducted in shallow water, and to illustrate a method for deriving the spectrum levels of wind-generated noise sources.

The ambient-noise data were measured in a shallow-water environment in the Ligurian Sea for five consecutive days at the end of November 1980. Broadband ambient-noise levels from a vertical string of hydrophones uniformly distributed over depth were recorded for 3 min every 1, 2, or 4 h according to variations in the wind speed. They were processed to form ambient-noise spectrum levels at frequencies from 50 to 3200 Hz at octave intervals, and then grouped as a function of wind speeds from 0 to 40 kn.

The method for deriving wind-induced source spectrum levels requires a well-controlled ambient-noise data set, a description of the environmental parameters influencing acoustic propagation at the experimental site, and an acoustic propagation model to compute site-dependent effects. Finally, the spectrum levels of the wind-generated noise sources are obtained from the wind-generated noise levels by removing the site-dependent propagation effects. A wind-generated noise model, based on the above method, has been jointly developed at SACLANTCEN <4,5> and at the U.S. Naval Research Laboratory, and can be used for estimating wind-induced noise levels for a given environment.

To gain confidence in the ability properly to compute site-dependent effects through the use of an acoustic propagation model, a propagation experiment was conducted prior to the ambient noise measurements and the results used in a detailed modelling of the test area.

In addition to acquiring the acoustic data, local shipping traffic was monitored by radar, expendable bathythermographs were taken, and local wind speed and wave height were recorded simultaneously.

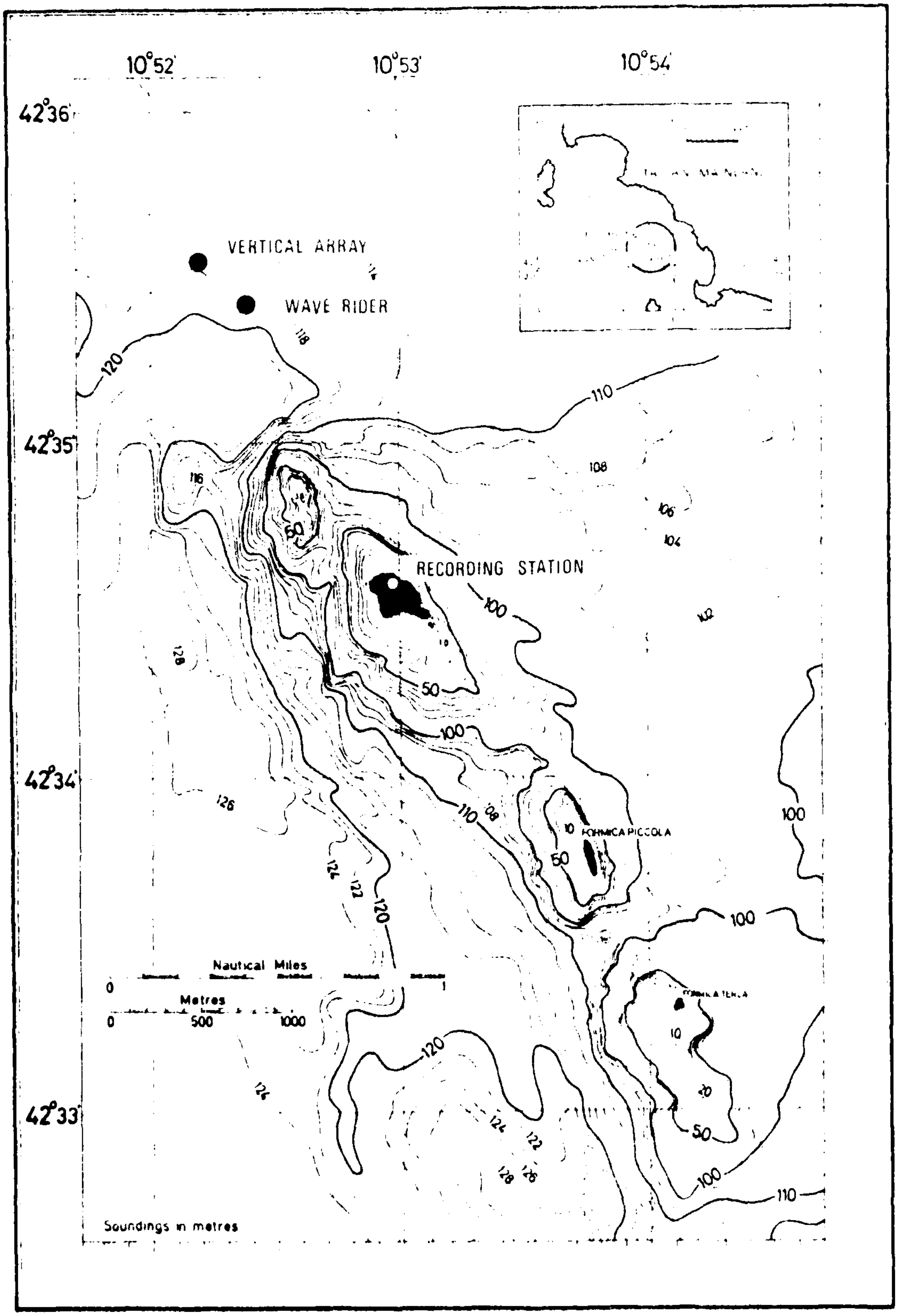

FIG. 1 EXPERIMENTAL AREA, SHOWING THE POSITIONS OF VERTICAL ARRAY, WAVERIDER BUOY, AND RECORDING STATION. The inset shows the position of the Formiche area relative to the Italian mainland.

1 ACOUSTIC MEASURING AND PROCESSING SYSTEM

The data were measured in shallow water off Formiche di Grosseto, a group of small islands southeast of Elba in the Ligurian Sea, for five consecutive days at the end of November 1980.

Figure 1 shows the relative positions of the instruments. The acoustic system, Fig. 2, consisted of a string of hydrophones suspended vertically between an anchor on the sea floor and a subsurface float. The hydrophones were connected by an armoured cable to instruments located in a lighthouse 2 km southeast of the measuring point. Broadband ambient-noise signals from the hydrophones were amplified and recorded on magnetic tapes for 3 min every 1, 2, or 4 h according to the variations in the wind speed.

The raw data for each hydrophone were low-pass filtered with a cut-off frequency of 4 kHz to prevent aliasing and then sampled and digitized at a rate of 12 kHz to form two 2-s sequences, 1 min apart, for each of the 3-min recordings of broadband raw data. Final estimates of the ambient-noise power spectra were obtained for each of the 2-s sequences at seven frequencies ranging from 50 to 3200 Hz at one octave interval using the averaging periodgram method <6>, with a 23.44 Hz bandwidth for each frequency estimate. Processing of the digital data also consisted of entering individual calibration constants and compensating for the effects of filtering and amplification.

In support of the noise measurements, wave-height data were measured with a Waverider buoy system located about 300 m southeast of the hydrophone array. Wind speed was measured by an anemometer installed on the lighthouse 20 m above the sea level. Bathythermographs were obtained by XBTs at intervals, and local shipping traffic was monitored with radar. Prior to starting the ambient-noise measurements a propagation-loss experiment was conducted using the vertical string of hydrophones as a receiver.

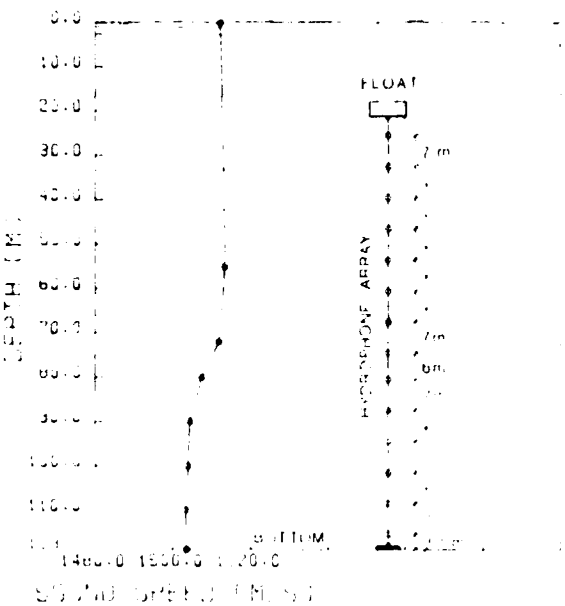

FIG. 2
HYDROPHONES DEPTH RELATIVE TO A TYPICAL SOUND-SPEED PROFILE TAKEN DURING NOVEMBER 1980 AMBIENT-NOISE MEASUREMENTS.

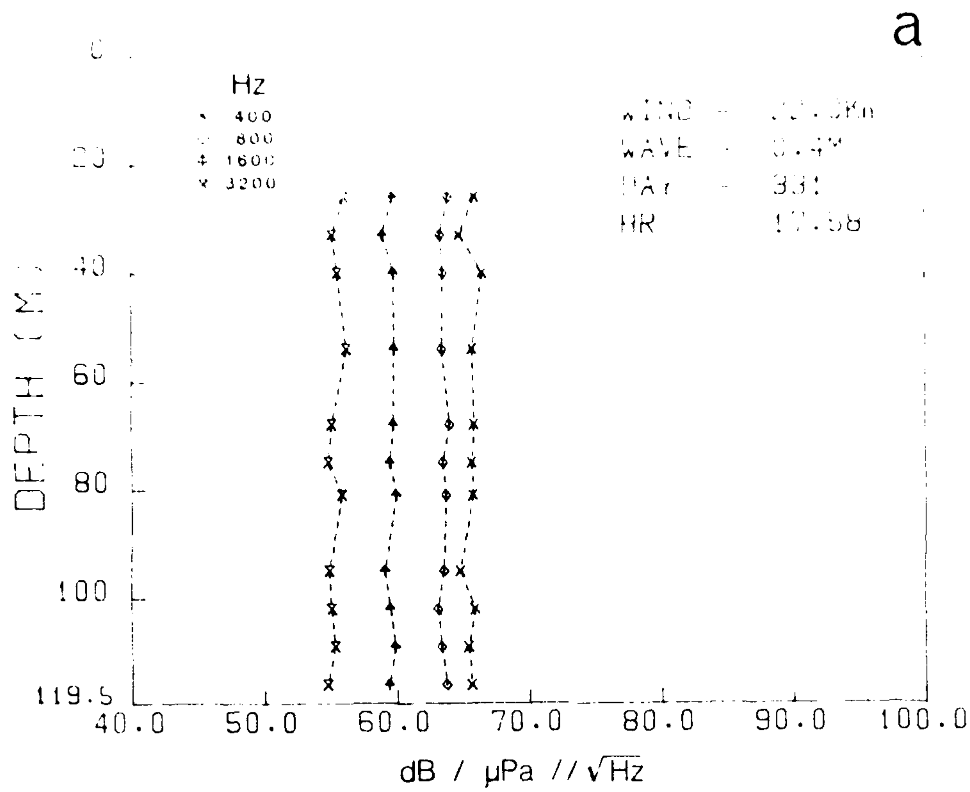

FIG. 3a VERTICAL DISTRIBUTION OF WIND-INDUCED NOISE MEASURED AT 22 kn WIND-SPEED.

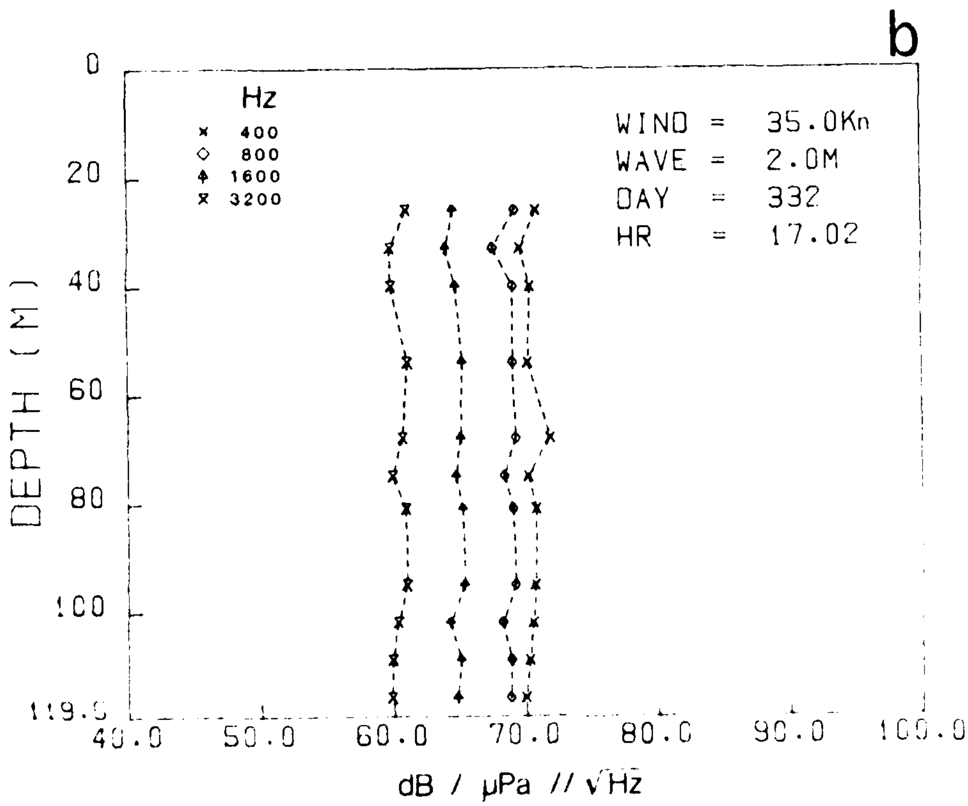

FIG. 3b VERTICAL DISTRIBUTION OF WIND-INDUCED NOISE MEASURED AT 35 kn WIND SPEED.

2 EXPERIMENTAL RESULTS

The analysis of the distribution of the noise over depth showed at times a substantial fluctuation at the near-surface and near-bottom hydrophones and more spikes at those depths than in the rest of the water column. The influence of cable strumming at the near-surface hydrophones and hydrophone failures at the bottom were suspected to play a major role in causing the variability at these near-boundary regions. The mid-water hydrophones showed the most stable results. However, at all frequencies, the noise level was constant over depth within a couple of decibels, as shown in Fig. 3, which gives the vertical noise intensity for two measurements selected during periods of minimum shipping noise. As seen in Fig. 4, this lack of depth dependence is also predicted by the noise model, which at 50 Hz indicates a variation of roughly 2 dB between 26 and 116 m depth. The depth-dependence progressively diminishes for increasing frequency.

After discarding the data that were too heavily contaminated by non wind-dependent noise sources, the final results were obtained by averaging, for each of the 3-min recordings, the ambient-noise power spectra computed for the three mid-array hydrophones.

The variation of the ambient-noise level versus time in the 50 to 3200 Hz octave bands and the corresponding variation in the wind speed and wave height are shown in Fig. 5. The wind speed, represented by the curve in the upper part of the plot, shows the wide variations typical of winter conditions. The data cover the period 24 to 28 November 1980.

As expected by previous studies, the time series of the noise levels at the higher frequencies show a striking resemblance to the wind-speed curve, confirming a strong wind dependence in the upper frequency band. The similarity diminishes with decreasing frequency. This is reasonable, since the observed spectra in this area can be primarily thought of as being a combination of two noise fields: wind-related noise and shipping noise. It is at these lower frequencies that ship-induced noise appears to be the primary contributor. In fact this figure shows a series of peaks at lower frequencies that are due to the presence of nearby ships identified by radar. The only exception is the peak appearing around day 332, which is due to heavy rainfall. Here the level increases by almost 30 dB at 3200 Hz, but is less intense at lower frequencies. The noise levels remaining after deleting the data suffering from the obvious effects of nearby ships and rain have been ordered according to the wind speed and then a best-fit second-order polynomial has been computed.

Figure 6 shows the experimental data for all octave bands in the 50 to 3200 Hz band as a function of wind speed from 0 to 40 kn, together with a quadratic, least-squares fit of the data, and with reference levels obtained from a summary of wind-induced deep-water ambient-noise spectra <7>.

We can immediately observe that at 50 and 100 Hz the noise levels are much higher than the reference levels and that they show no dependence on wind speed. It is believed that these levels depend on the distant ship

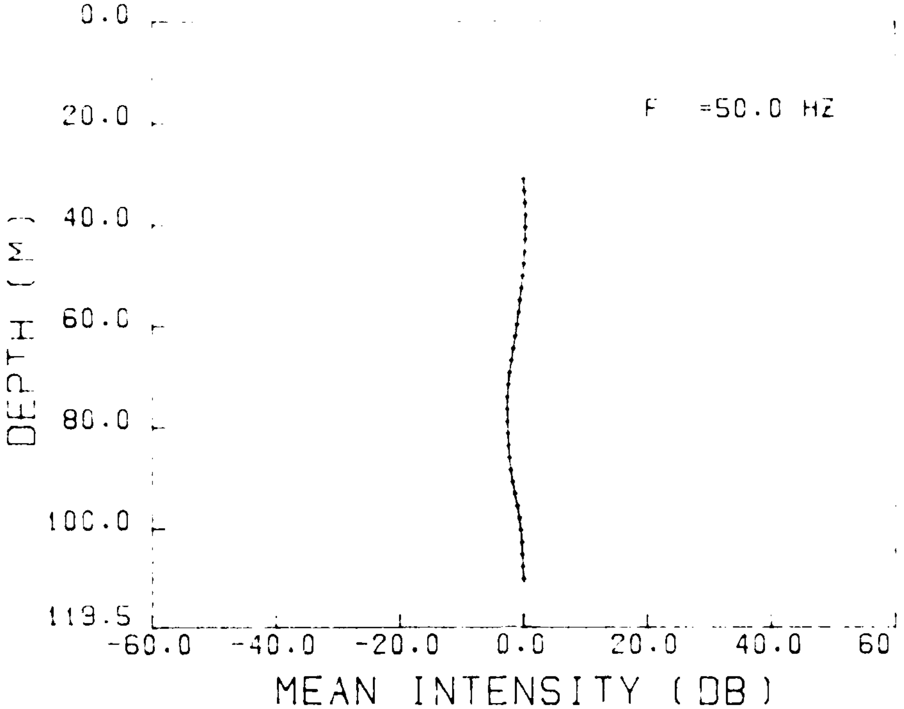

FIG. 4 VERTICAL DISTRIBUTION OF WIND-INDUCED NOISE AS COMPUTED BY THE MODEL FOR UNIT SOURCE STRENGTH.

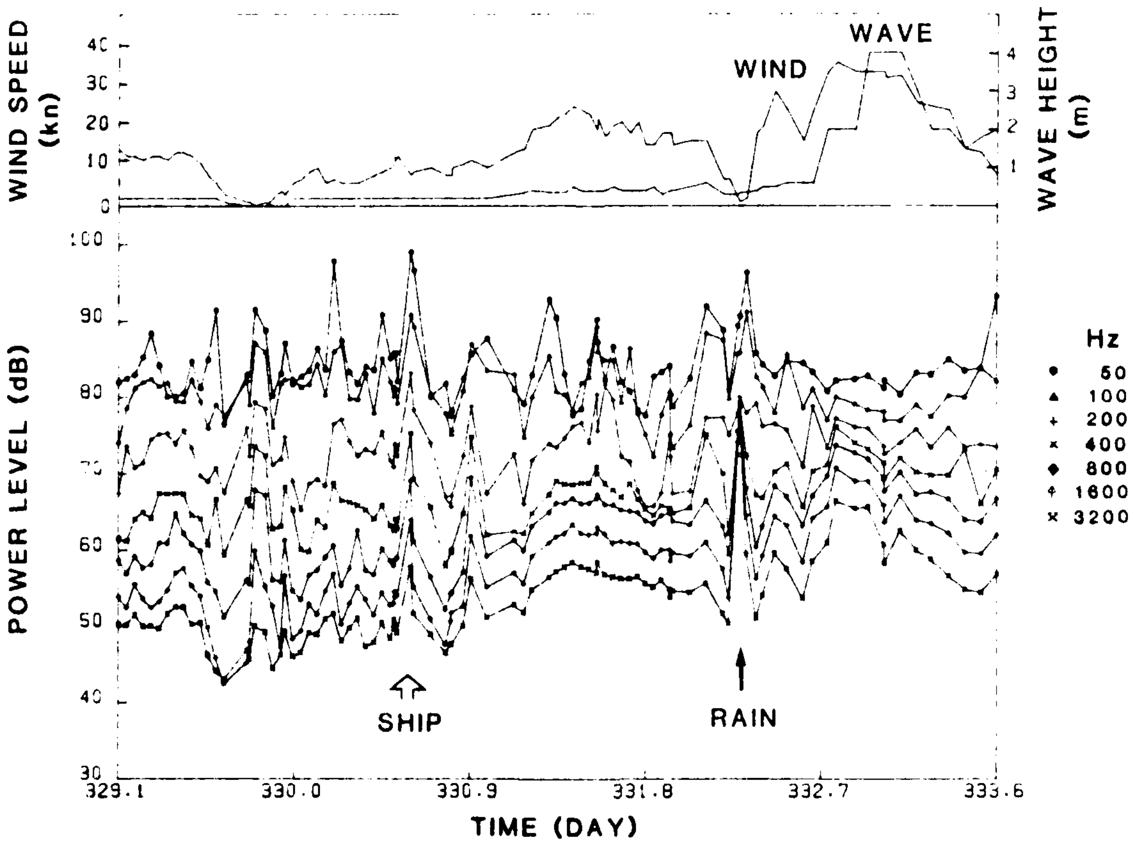

FIG. 5 VARIATION OF WAVE HEIGHT, WIND SPEED, AND SHALLOW-WATER AMBIENT NOISE LEVELS AS A FUNCTION OF TIME.

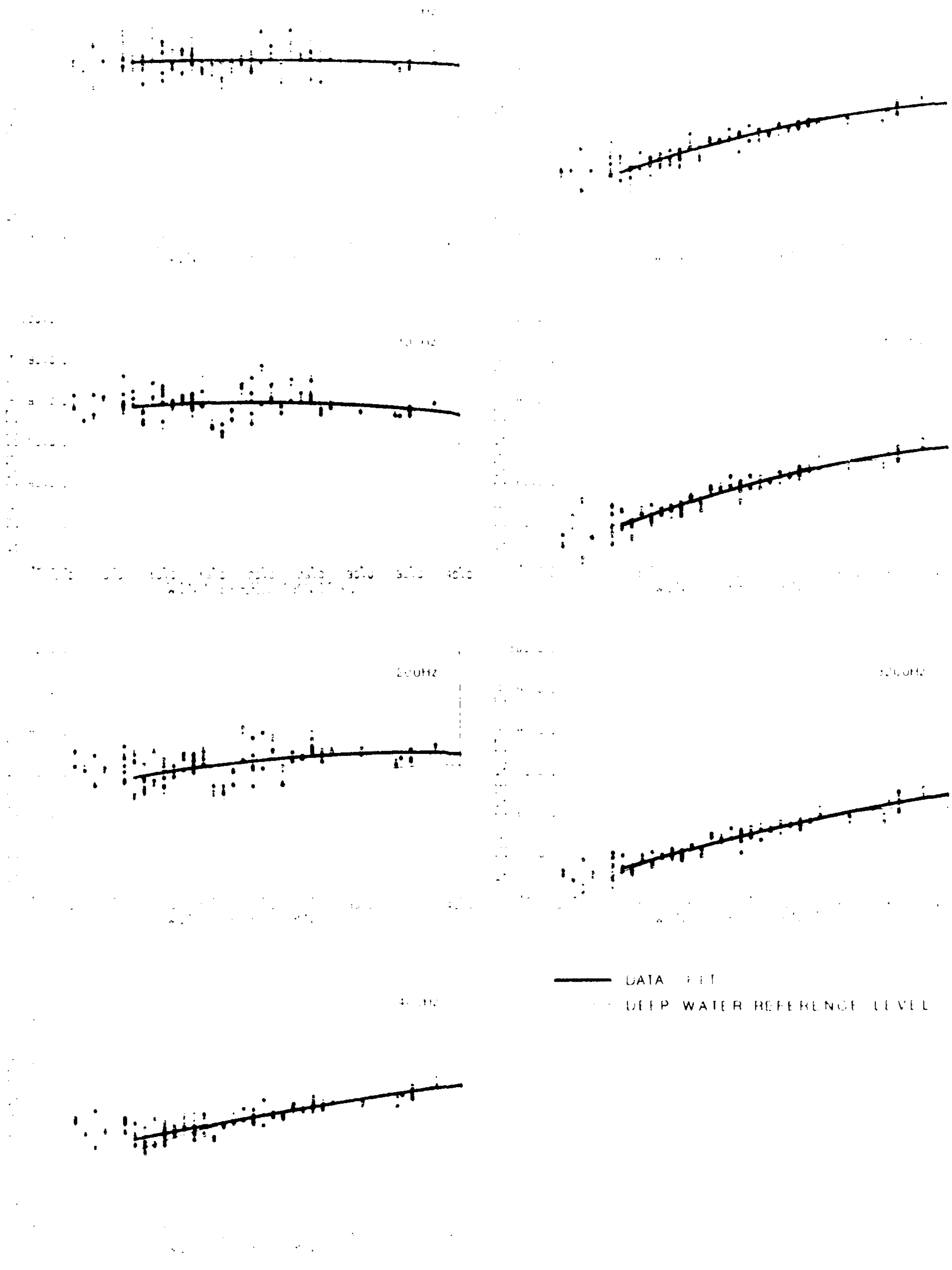

FIG. 6 SHALLOW-WATER AMBIENT-NOISE LEVELS FOR WIND SPEEDS FROM 0 TO 40 kn AND FOR FREQUENCIES FROM 50 TO 3200 Hz AS FROM REFERENCE DEEP WATER TABLES AND THE PRESENT STUDY.

traffic, which is quite intense in the test area. At 200 Hz we begin to observe a weak wind-speed dependence, while from 400 Hz up to 3200 Hz the wind-speed dependence increases and the levels are in good agreement with the reference levels for wind speeds greater than 7 kn. However, even with the best agreement, the noise levels show no clear dependence on wind speed for wind speeds less than 7 kn.

The levels obtained from the experimental data through the curve-fitting polynomials are shown again in Fig. 7, where they are compared with the reference deep-water levels for different wind speeds and with average levels for various shipping densities. It is important to notice that the wind-induced noise at the Formiche di Grosseto site is less than that usually assumed for shallow water areas. The wind-speed relationship is approximately the same as the deep-water results of Ross <7>, a fact which is believed to depend on the soft bottom in the test area.

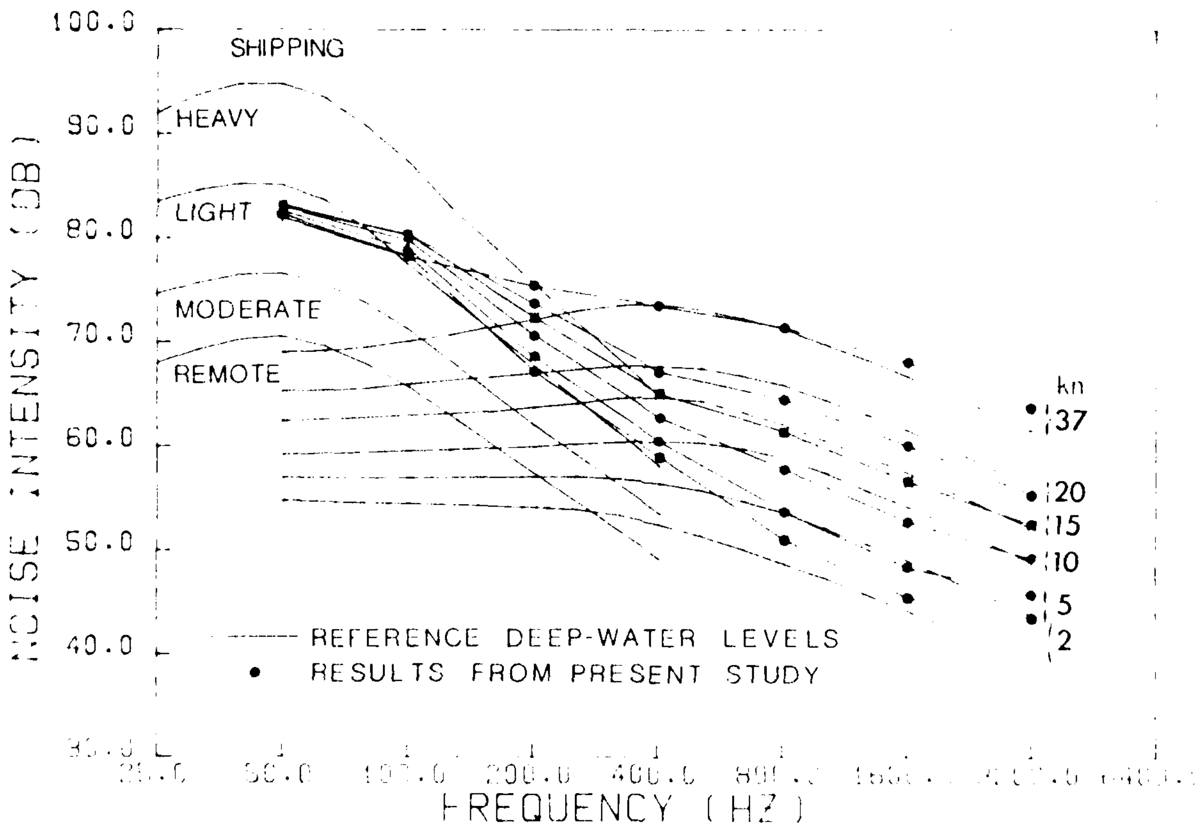

FIG. 7 SHALLOW-WATER AMBIENT-NOISE LEVELS FOR VARIOUS BEAUFORT WIND SPEED GROUPINGS AND FOR FREQUENCIES FROM 50 TO 3200 Hz AS FROM REFERENCE DEEP WATER TABLES AND THE PRESENT STUDY.

3 MODELLING OF WIND-GENERATED NOISE

The frequency dependence of the noise measured some distance away from the noise source can be substantially different from the frequency dependence of the radiated noise at the source <2>. This may be particularly true when sound propagation is controlled by the acoustic properties of the bottom, such as in shallow water areas.

To properly take account of the effect of the environmental parameters influencing the acoustic propagation and to include both the discrete and the continuous components of the acoustic field, we have developed a wind-generated noise model based on the combination of two acoustic propagation models: a normal-mode model (SNAP) <8>, which calculates the propagating modes (discrete field), and a fast field program (FFP) <9>, which calculates the nearfield contribution (continuous field). The wind-generated noise model has been jointly developed by the US Naval Research Laboratory and SACLANTCEN. The mathematical concepts are described in <4>. The wind-generated noise sources are modelled as uncorrelated monopole sources. Different source directionalities have been studied by Hamson <10> and could easily be incorporated in the model.

The acoustic propagation models treat the ocean as a three-layered medium. The first two layers describe the water column and the sediment, with the sound-speed profile arbitrarily varying with depth while the density is held constant for each layer. We include volume attenuation in the water layer and attenuation of compressional waves in the sediment layer. The third layer is a semi-infinite solid layer with constant properties such as density and sound speed and with attenuation of compressional and shear waves. The SNAP model used for calculating the discrete modes of the acoustic field includes scattering loss at a rough sea surface or bottom <11>.

The propagation-loss data collected before starting the ambient-noise measurements were analyzed and modelled with the SNAP model, using the XBT data taken during the experiment and the average bottom parameters derived from a previous study of the test area <12>. Figure 8 compares the experimental and model results. The close agreement evident in this figure indicates that both the actual decibel levels and the frequency dependence of propagation (which has been shown to be indicative of the environment <13>) are correctly predicted by the model and confirm the previous definition <12> of bottom parameters for that area.

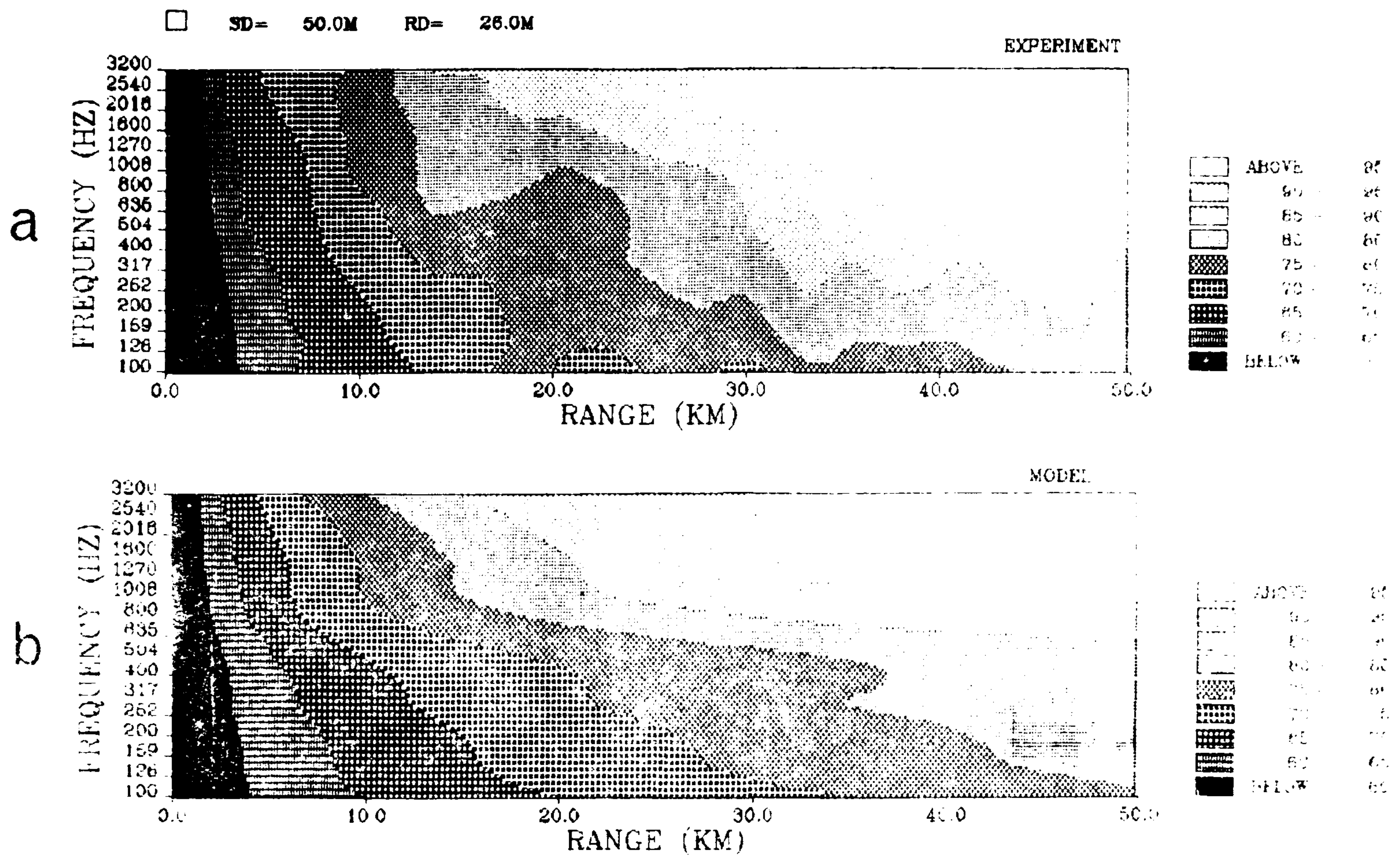

FIG. 8 CONTOURS OF PROPAGATION LOSS IN THE TEST AREA
a) Experimental result.
b) Model result.

4 SOURCE SPECTRUM LEVELS

To determine the source spectrum levels, we start from the following expression:

$$T(z,z') = q^2 * SF(z,z') \;, \qquad \text{(Eq. 1)}$$

where

$T(z,z')$: Total intensity at depth z from sources located at depth z' over the entire source plane.

q : Source strength term expressed in dB//µPa/√Hz

$SF(z,z')$: Discrete (SNAP) and continuous (FFP) contributions to the acoustic field integrated over the entire source plane.

If we now replace $T(z,z')$ with the actual noise level $E(z,z')$ obtained from the experiment at sea, we can compute the source spectrum level as:

$$SL(z') = 10 \log q^2 = 10 \log E(z,z') - 10 \log SF(z,z') \;. \qquad \text{(Eq. 2)}$$

Hence in effect we are subtracting the environmental effects to isolate the source spectrum levels. Values are computed from the noise model for source depths satisfying the following relation:

$$z' \ll c/2w$$

and are referred to a 0 m source depth by applying the following expression <14>:

$$SL(0) = SL(z') + 10 \log (1/z'^2) \;. \qquad \text{(Eq. 3)}$$

By applying Eqs. 2 and 3 we can now derive the wind-generated source spectrum levels. However, in the Formiche di Grosseto area the analysis of the ambient-noise data shows that below frequencies of 400 Hz wind-independent noise sources dominate the band, thus allowing the source spectrum levels to be estimated only at frequencies from 400 to 3200 Hz.

To also obtain a rough estimate of the frequency dependence of the wind-generated source spectrum levels for frequencies below 400 Hz, we have used the noise model and Ross's ambient-noise reference curves <7> to derive source spectrum levels for a typical winter deep-water profile. The computed source spectrum levels derived both from our shallow-water data and from the deep-water reference curves are shown in Fig. 9, where they

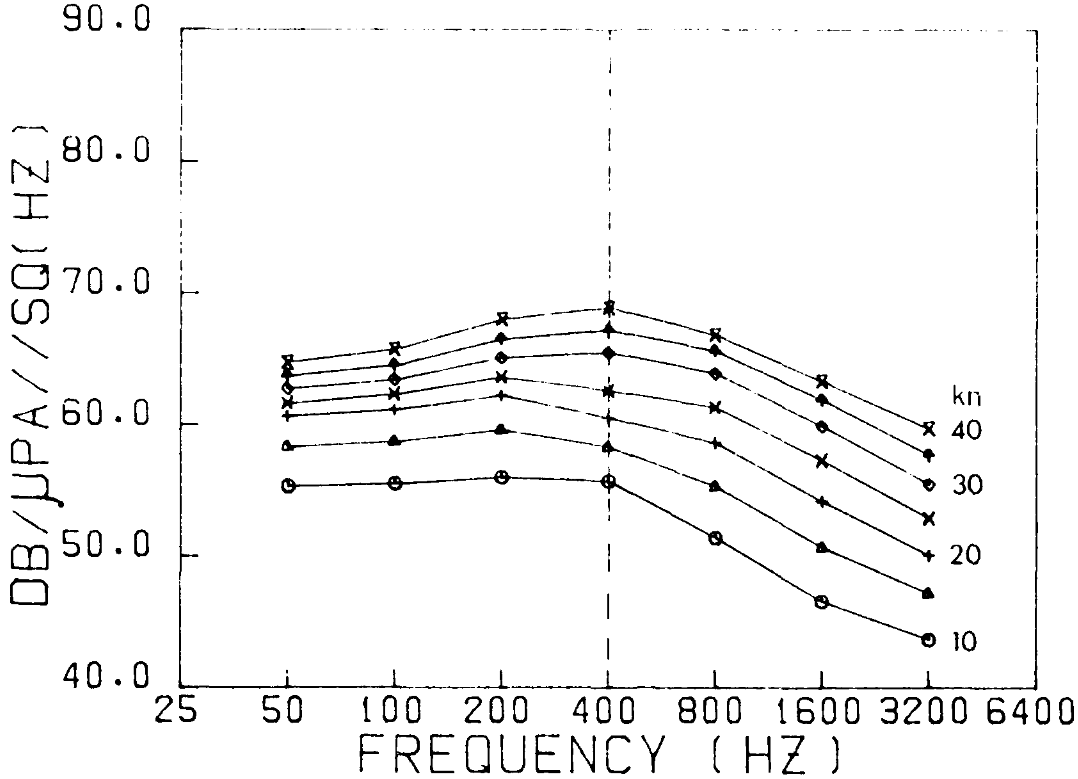

FIG. 9 SOURCE SPECTRUM LEVELS OF WIND-GENERATED NOISE AT VARIOUS WIND SPEEDS IN THE 10 TO 40 kn INTERVAL AND FOR FREQUENCIES FROM 50 TO 3200 Hz.

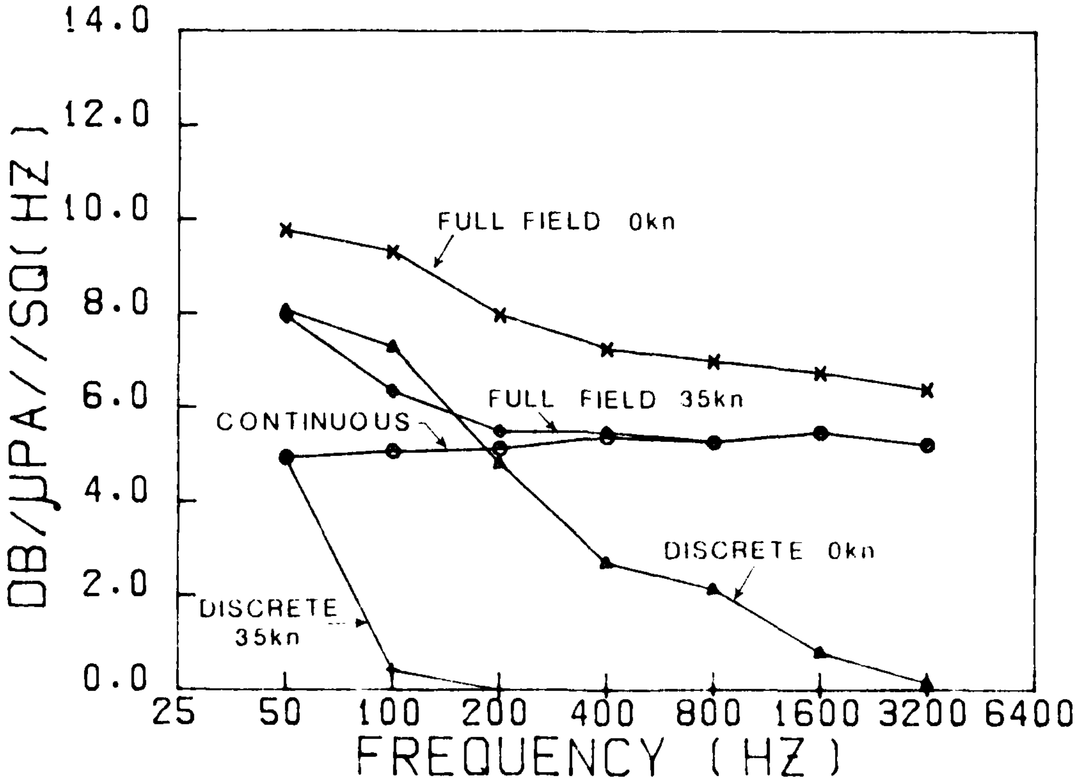

FIG. 10 INDIVIDUAL CONTRIBUTION OF THE CONTINUOUS, DISCRETE, AND FULL FIELD COMPONENTS OF THE ACOUSTIC FIELD IN THE FORMICHE AREA.

are plotted for selected wind speeds between 10 and 40 kn. There is a smooth transition from one derivation to the other, except at the lowest wind speed. These results show a similarity to the spectral shape of splash noise, as reported by Franz <15>, where the spectrum peaks between 300 and 600 Hz. This is consistent with the conjecture that the air/sea interaction giving rise to wind-generated noise is physically related to the splash-noise phenomenon <7>.
We have made a comparison with Wilson's <16> source spectrum levels at wind speeds from 10 to 40 kn and for frequencies from 400 Hz (lowest frequency in our noise data with minor non-wind-dependent noise influence) to 1000 Hz (the highest frequency analyzed by Wilson). Within these limits the agreement is generally very good except at the lowest wind speed. However, below 400 Hz the agreement is seen to be poor. The explanation for this low-frequency disagreement is not known.

Ingenito and Wolf <3> also show source spectrum levels as a function of wind speed at 500 and 1000 Hz. Their results are roughly 5 dB higher at low wind speeds, with the difference increasing slightly with increasing wind speed. Although the results being compared were obtained by following the same technique, the calculation of the propagation effects in the two cases differs in that we have described the continuous component of the acoustic field exactly, using the FFP technique <9>.

The relative importance of the continuous and the discrete components of the acoustic field, at the Formiche di Grosseto area, is indicated by Fig. 10, which presents the two components computed from the noise model for frequencies from 50 to 3200 Hz at wind speeds of 0 and 35 kn. The main feature evident in this figure is that while the continuous field contribution is virtually constant with frequency, the contribution of the discrete field to the total ambient-noise level decreases with increasing wind speed and frequency. The strong attenuation of the discrete field is caused by scattering at the rough sea surface. Although we believe that this is a true effect, we note that our propagation model treats scattering loss in an approximate way that might lead to over-estimating this loss mechanism.

CONCLUSIONS

The main conclusions of this study concerning wind-generated noise in the Formiche di Grosseto area are:

a. The noise is wind-induced for frequencies greater than 400 Hz, when excluding the time-resolved contributions of nearby ships.

b. Noise levels are correlated more with wind speed than with wave height, although for wind speeds of less than 7 kn there is not significant correlation.

c. Over the depth interval covered (26 m to 116 m), the wind-induced noise is essentially depth independent.

d. Both the level and the frequency dependence of the wind-induced component are in good agreement with the deep-water reference curves of Ross <7> for frequencies above 400 Hz.

e. The correspondence between the measured noise and reported deep-water noise is consistent with the acoustic environment for this particular shallow water site.

f. The frequency dependence of the source spectrum levels shows a similarity to the spectral shape of splash noise as reported by Franz <9>, where the spectrum peaks between 300 Hz and 600 Hz. This is consistent with the conjecture that the air/sea interaction giving rise to wind-generated noise is physically related to the splash-noise phenomenon <7>.

g. The derived source level for frequencies below 400 Hz differs significantly from that of Wilson <16>. Our result in this case may not be considered conclusive, because in applying our method for deriving source spectrum level we could not use data from a controlled experiment.

h. The analysis of the noise model results shows that, at high wind speeds, the relative contribution of the continuous field to the total ambient-noise field is more important than that of the discrete components, resulting in a virtually constant noise intensity over depth. The strong attenuation of the propagating modes for frequencies above 400 Hz is due to scattering loss at the rough sea surface <11>. This effect, which increases with increasing wind speed and frequency, reduces the importance of the contributions from distant sources. Consequently, very elaborate modelling of propagation effects is not needed at high wind speeds.

REFERENCES

1. URICK, R.J. Principles of Underwater Sound for Engineers, New York, N.Y., McGraw-Hill, 1967: 169-170.

2. WILSON, J.H. Very low frequency (VLF) wind-generated noise produced by turbulent pressure fluctuations in the atmosphere near the ocean surface. Journal of the Acoustical Society of America, 66, 1979: 1499-1507.

3. WOLF, S.N. and INGENITO, F. Site dependence of wind-dominated ambient noise in shallow water. In: WAGSTAFF, R.A. and BLUY, O.Z., eds. Underwater ambient noise. Proceedings of a conference held at SACLANTCEN on 11-14 May 1982, SACLANCEN CP-32, Part 2. La Spezia, Italy, SACLANT ASW Research Centre, 1982: pp. 22-1 to 22-9.

4. KUPERMAN, W.A. and INGENITO, F. Spatial correlation of surface generated noise in a stratified ocean. Journal of the Acoustical Society of America, 67, 1980: 1988-1996.

5. JENSEN, F.B. and KUPERMAN, W.A. Environmental acoustic modelling at SACLANTCEN, SACLANTCEN SR-34. La Spezia, Italy, SACLANT ASW Research Centre, 1979. [AD A 081 853]

6. RABINER, L.R., SCHAFER, R.W. and DLUGOS, D. Periodogram method for power spectrum estimation. In: INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS. ACOUSTICS, SPEECH, AND SIGNAL PROCESSING SOCIETY. Programs for digital signal processing. New York, N.Y., IEEE, 1979. pp. 2.1-1 to 2.1-10.

7. ROSS, D. Mechanics of Underwater Noise. Oxford, U.K., Pergamon Press, 1976: 69-71.

8. JENSEN, F.B. and FERLA, M.C. SNAP: The SACLANTCEN normal-mode acoustic propagation model, SACLANTCEN SM-121. La Spezia, Italy, SACLANT ASW Research Centre, 1979. [AD A 067 256].

9. KUTSCHALE, H.W. Rapid computation by wave theory of propagation loss in the Arctic Ocean, TR CU.8.73. Palisades, N.Y., Columbia University, Lamont Geological Observatory, 1973.

10. HAMSON, R.M. The theoretical response of a vertical array to wind-generated noise in shallow water. SACLANTCEN memorandum (in preparation).

11. KUPERMAN, W.A. and INGENITO, F. Attenuation of the coherent component of sound propagation in shallow water with rough boundaries. Journal of the Acoustical Society of America, 61, 1977: 1178-1187.

12. JENSEN, F. Comparison of transmission loss data for different shallow-water areas with theoretical results provided by a three-fluid normal-mode propagation model. In: HASTRUP, O.F. and OLESEN, O.V., eds. Sound propagation in shallow water. Proceedings of a conference held at SACLANTCEN on 23-27 September 1974, SACLANTCEN CP-14. La Spezia, Italy, SACLANT ASW Research Centre, 1974: 79-92.

13. JENSEN, F.B. and KUPERMAN, W.A. Optimum frequency of propagation in shallow water environments. Journal of the Acoustical Society of America, 73, 1983: 813-819.

14. INGENITO, F. Place. Unpublished manuscript.

15. FRANZ, G.J. Splashes as sources of sound in liquids. Journal of the Acoustical Society of America, 31, 1959: 1080-1096.

16. WILSON, J.H. Wind generated noise modeling. Journal of the Acoustical Society of America, 73, 1983: 212.

KEYWORDS

ACOUSTIC PROPAGATION
AMBIENT NOISE
BOTTOM COMPOSITION
BROADBAND
COMPRESSIONAL WAVES
CONTINUOUS FIELD
DISCRETE FIELD
FAST FIELD PROGRAM
FFP
FORMICHE DI GROSSETO
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